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13. ABSTRACT *(Maximum 200 words)*

Research investigations and development of the fast adaptive algorithms using orthonormal bases with controlled localization in the time-frequency domain (e.g. wavelets) have been successful and several new algorithms have been developed. Among the results is the Unequally Spaced Fast Fourier Transform (USFFT) algorithm and a new approach to numerical homogenization.

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***Nonlinear Problems* in Fluid Dynamics and Inverse Scattering**

Principle Investigator: Gregory Beylkin

Subtitle: Propagation and capturing of singularities in problems of fluid dynamics and inverse scattering

Program Manager: Dr. Reza Malek-Madani

Annual Progress Report

Research investigations and development of the fast adaptive algorithms using orthonormal bases with controlled localization in the time-frequency domain (e.g. wavelets) have been successful and several new algorithms have been developed. Among the results is the Unequally Spaced Fast Fourier Transform (USFFT) algorithm and a new approach to numerical homogenization.

Research Activities:

Using a Battle-Lemarie scaling function we have constructed a fast algorithm to evaluate the Fourier transform of generalized functions. In particular, we have developed an algorithm for the Unequally Spaced Fast Fourier Transform and tested its performance in dimensions one and two. Also we have a new algorithm to evaluate the Fourier Transform of an image, taking into account the discontinuities within the image. Our approach also has implications for numerical solutions of PDE's which we plan to investigate further.

Jointly with Mary E. Brewster, we have constructed a numerical scheme for homogenization of linear differential and difference equations via multiresolution analysis. This work has a potential for a significant impact by permitting us to construct the equations for computing the projection on a sparse scale of the solution of equations given on very fine scales.

Jointly with John Dunn and David Gines, we developed a practical hybrid method for solving Static and Quasi-Static problems in Electromagnetics using wavelets.

Jointly with Bruno Torresani, we developed a method of applying operators in wavelet bases. This method is different from both standard and non-standard forms that have been developed previously and is very efficient for convolution operators, e.g. the Hilbert transform.

A new efficient method for design of FIR Approximation of IIR Filters has been developed. We use a "non-traditional" approach to this problem.

The work with James Keiser on solving partial differential equations in wavelet bases has continued. The results will be published shortly.

The work with Robert Cramer on the multidimensional algorithms for the fast evaluation of a class of integral operators on functions is producing results. We also expect to release these results shortly.

Published Papers:

"Wavelets and Fast Numerical algorithms", G. Beylkin, Proceedings of Symposia in Applied Mathematics, vol. 47, 1993

Preprints:

"On Factored FIR Approximation of IIR Filters", G. Beylkin, November 1993, PAM Report #181

"Implementation of Operators Via Filter Banks, Autocorrelation Shell and Hardy Wavelets", G. Beylkin and B. Torresani, February 1994, PAM Report #185

"A Multiresolution Strategy for Numerical Homogenization", M.E. Brewster and G. Beylkin, March 1994, PAM Report #187

"Order N Static and Quasi-Static Computations in Electromagnetics Using Wavelets", G. Beylkin, J. Dunn, and D. Gines, April 1994, PAM Report #189

"On Fast Fourier Transform of Functions With Singularities", G. Beylkin, June 1994, PAM Report #195

"Fast and Accurate Computation of Fourier Transform of an Image", G. Beylkin, July 1994, PAM Report #206